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Using scale-dependent observational data for snow modelling in a glacierized catchment

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Snow cover distribution and melt are essential to understand and to predict runoff. However, the spatial heterogeneity of snow cover in complex terrain and the limited availability of observational data make distributed modelling of snow covered area (SCA) and of snow water equivalent (SWE) in alpine regions still a challenging task. A promising approach is the application of physically based distributed hydrological models coupled with ground observations and with new satellite products. However, the inherent complexity of advanced models and satellite products requires an accurate evaluation both at plot and at catchment scale before their operational use.
In this context we evaluate the capability of the new model GEOtop 2.0 for the first time to simulate snow dynamics at plot and at catchment scale. Our study was performed in the upper Saldur basin (61 km^2) in the Eastern Italian Alps during the period 2010 – 2013.
At plot scale, simulated snow depths and SWE were calibrated against measured snow depth data from multiple measuring sites at different elevations (at 1930 m, at 1998 m, at 2450 m, and 3035 m a.s.l.) in and close to the Saldur basin. The evaluation was quantified by the statistical indices R^2 and the Nash-Sutcliffe efficiency. Different model parameterisations were evaluated by a manual sensitivity analysis of 11 key parameters controlling the snowpack and the meteorological input data. Most of these key parameters found to be sensitive for SWE and for snow depth were the ones controlling albedo decreasing and precipitation input.
At catchment scale, simulated SCA of the upper Saldur basin was calibrated against the daily composite 250 m EURAC MODIS SCA (Notarnicola et al. 2013) and then validated against Landsat 7 ETM+ SCA (at 30 m resolution). The model evaluation was supported by a pixel-based calculation of overall accuracy (Parajka and Blöschl 2008) of total SCA in the upper Saldur basin. Additionally, the snow presence derived from simulated SCA and MODIS SCA was evaluated against measured snow depth as ground truth data derived from the measuring sites.
The same parameterisations, which were sensitive at plot scale showed good agreement with MODIS SCA, in particular for single snow events in autumn. These results confirm that model parameters were successfully transferred from plot scale to catchment scale. However, less agreement was found in zones with forest and steep slopes greater than 45°. Further investigations are needed to assess the uncertainties both of the hydrological model but also of the MODIS composite product in relation to different thresholds of snow depths and cloud cover.

Keywords: snow cover, hydrological modelling, MODIS, plot and catchment scale, uncertainty.